PROTECTION REVIEW

Terms of Reference

1.0 Introduction

The Electric Power Corporation (Samoa) is looking for a consultant(s) to carry out a comprehensive review of its protection system. This Request for Proposal is for this purpose.

EPC is the biggest electricity producer in Samoa with its generation mix of Diesel and Renewables in form of Hydro, Solar and Wind. It also owns 100% of the transmission and distribution network. The reliable performance of EPC system network protection is a pre-requisite for the reliability and quality of electricity supply to consumers while operating the system in an economically efficient way

Samoa consists of four inhabited islands with the second biggest one (Upolu) responsible for 90% of electricity consumption. The EPC system is comprised of hydro, solar, wind and diesel generation units. Its goal is to be 100% Renewable by the year 2025. EPC's drive for a 100% renewable power system, continues with the addition of new GHG-free generation assets either by the corporation itself, or from the independent producers. However, the integration of more renewable sources into the power system will reduce the number of conventional units that provide primary frequency control and inertia response.

Table 1 : Overview of load breakdown

	Island	Load Demand	Description
	Savaii	3.2 MW	Mixture of diesel, solar and hydro
	Upolu	25 MW	Mixture of diesel, hydro, solar and wind
	Manono	Load is part of Upolu	Connected to Upolu via a submarine cable and is part of the Lefaga Feeder
	Apolima	Load is so small that it is not significant	100% Solar

In addition to EPC's generations, there are also Independent Power (IPPs) Producers who generate and sell electricity to EPC. These three IPPs are all located on the island of Upolu and generate electricity by the means of solar. Table 2 below lists the complete generation sources available to EPC

Table 2 : Power Stations Available Capacity

EPC Diesel Power Stations			
	Station	**Available Capacity**	**Location**
1	Fiaga Power Station	24 MW	Upolu
2	Tanugamanono Power Station	4.5 MW	Upolu
3	Salelologa Power Station	4.95 MW	Savaii
EPC Renewable Stations			
	Station	**Available Capacity**	**Location**
4	Alaoa Hydro	1.05 MW	Upolu
5	Fale ole Fee	3.5 MW	Upolu
6	Samasoni Hydro	1.9 MW	Upolu
7	Taelefaga Hydro	4 MW	Upolu
8	Lalomauga Hydro	3.5 MW	Upolu
9	Tafitoala Hydro	0.46 MW	Upolu
10	Faleata Hydro	0.16 MW	Savaii
11	Vaitele Solar	0.25 MW	Upolu
12	Tanugamanono Solar	0.15 MW	Upolu
13	Gym 3 Tuanaimato Solar	0.204 MW	Upolu
14	Vailoa Aleipata Wind Farm	0.5 MW	Upolu
15	Salelologa Solar Farm	0.25 MW	Savaii

16	Tuanaimato Racecourse Solar	2 MW	Upolu
	Independent Power Producers (Solar)		
	Station	**Capacity**	**Location**
17	Solar for Samoa Racecourse	1.5 MW	Upolu
18	Solar for Samoa Airport	2.2 MW	Upolu
19	Sun Pacific Energy	3.4 MW	Upolu
20	Green Power Racecourse	2.2 MW	Upolu
21	Green Power Airport	2.5 MW	Upolu

For this assignment, the study will focus only on the island of Upolu as it is the one where 90% of electricity is used.

Transmission on Upolu is achieved via two levels of voltages, 22kV and 33kV. There are three pure transmission lines. The transmission can be better characterized as a combination of pure transmission and distributed transmission systems. Fiaga the biggest power station generates electricity and then transmits most of it to the Fuluasou Substation also known as the National Control Center where it will then distributed to various feeders. There are also two distribution feeders fed direct from the Fiaga Power Station. Fuluasou Substation is connected to Tanugamanono Substation via an underground 33kV transmission tie. The hydro stations at Lalomauga, Samasoni, Alaoa, Fale o le Fee and Taelefaga are connected to Tanugamanono via pure transmission or distributed/transmission lines.

<u>Pure Transmission Lines</u>

- Fiaga/Fuluasou Overhead Tie – 33kV
- Fiaga/Fuluasou Underground Tie – 33kV
- Fuluasou/Tanuagamanono Underground Tie – 33kV

<u>Transmission/Distribution lines</u>

- Talefaga/Lalomauga Overhead Tie – 22kV

- Lalomauga/Tanugamanono Overhead Tie – 33kV

The Independent Power Producers located at the Tuanaimatou Racecourse are connected to Fuluasou Substation via West 2 distribution feeder. The IPPs located at the Airport are connected to Fiaga Power Station via the Lefaga distribution feeder.

All feeders and transmission lines are protected via the SEL Relay. With the exception of Alaoa and Lalomauga hydro stations, all of EPC's generations are protected via the same relay as well.

The last protection study was carried out by Northpower Ltd of New Zealand in 2010. The recommendations stated in the report had been implemented and new protection settings been incorporated into the system.

For the past five years, EPC has undergone a significant change in its system with the introduction of IPPs and the ever increasing penetration of Solar. This has introduced some major problems to EPC's network particularly in terms of grid stability as these solar farms do not come with storage. As a solution, EPC has installed and commissioned a BESS system and a microgrid controller to manage its network operations. EPC now has a good chance to go 100% renewable on weekends and holidays when the power demand is not as high, however it has been observed that there have been some protection issues that have surfaced as a result.

With the Government of Samoa's drive to become 100% renewable by the year 2025 and the last protection study having occurred before this massive renewable penetration, the project objectives include:

1. Well coordinated protection between the generating stations, distribution feeders and the transmission system
2. Well-coordinated protection between the EPC system and IPPs
3. Better discrimination amongst feeder protections,
4. Reliable power supply,
5. Better load flow control (voltage control and reactive power compensation)
6. High system efficiency
7. Improving of an Automatic load shedding system at power plants and substations to automatically trip feeders if there is insufficient generation available when one or more than one generators suddenly trip on a fault.
8. Better coordination between the overall system protection and microgrid

9. Recommendation for fault current settings given the various scenarios

The consultancy firm shall review the performance of the net work and advice the way forward of improving it.

The implementation of the outcome of the above consultancy services is expected to improve the quality of power supply to the customers. Further, due to good supply of electricity, reaction regarding to customers claims on bad electricity supply will be reduced.

2.0 Scope of Works

To achieve the above objectives the successful consultancy firm will perform the following consultancy services which shall anticipate two types of studies namely Load Flow study and System Protection study:

The Grid Transmission network includes all generation stations, the 33kV transmission lines, 22kV distribution feeders and two 33/22kV sub-stations. In this study the consultancy firm shall work under the following scope of activities:

1. Review existing future load forecast and develop network models
2. Review system performance statistics, and collect generation and transmission technical characteristics data.
3. Develop Transmission model for studies on switching, Load Flow (steady-state & contingency) and dynamic simulations of various network operational scenarios.
4. Develop various network operational scenarios based on Generation schedules, seasonal loads (wet / dry), voltage control equipment schedules and network configurations.
5. Investigate network phenomena as required to understand network behaviour, identify operational deficiencies and propose possible solutions to improve the operational performance of the transmission and the distribution network and review Grid system forced outage statistics including total initial restoration from blackouts with the objective of minimising the outage duration and improving the supply security.
6. Utilising power system simulation tool (DigSILENT's Power factory is the one used by EPC) to conduct power system simulations to assess operational adequacy of the Transmission network (Switching, Load Flow, Contingency and Dynamic simulations)

and review the Voltage control, profiles and reactive power compensation on the grid.

7. Propose the type and quantity of reactive power compensation required to be installed in the system in order to maintain voltage levels within acceptable international standards.
8. Review the generation operational settings on governors and the under-frequency load shedding system settings to ensure optimum system stability under system disturbances.
9. Review EPC operations and protection system and design particularly the frequency load shedding system for the distribution feeders
10. Review the entire distribution network and recommend appropriate feeder loadings and distance given the protection available
11. Test and verify the accuracy of the SEL relay as used as KWH meters on feeder circuits with the objective of ensuring that the accuracy of the meters is within the accepted standards in order to accurately monitor and audit system losses.
12. Propose for methods to provide inertia
13. Provide a complete report of the study with models that can be used by EPC for monitoring and forecasting of system behaviour.

3.0 System Protection Study

The system protection comprises of all measuring, monitoring and protection devices and switchgear installed on the Grid net work. The scope of works under this study shall include:

1. Review of transmission database and come up with correct version which predicts the transmission line parameters as per their configuration.
2. Review of existing protection performance
    a. Overcurrent protection for feeders
    b. Under-frequency Load Shedding system and philosophy
    c. Operational setting of generator governors
    d. Microgrid behaviour and recommend improvements
    e. Differential protection for transmission lines

f. Distance protection settings

g. Auto-Reclosers functionality

3. Review and recommend fault current settings under the following scenarios

    a. Full generation mix with hydro, diesel, solar and wind

    b. Partial generation mix with hydro and diesel only

    c. Full Renewable generation mix with hydro, solar and wind

    d. Full Renewable with solar only

    e. Recommend suitable ways to produce system inertia in the event of a 100% renewable generation mix

4. Review of coordination between EPC and IPP protection systems

5. Review installed measuring, monitoring and protective devices in sub-stations and stations and advice on their suitability and accuracy going forward.

6. Review the utilisation of the SEL Relay and recommend unused relay features that will improve the EPC system.

7. Steady state load flow calculations considering voltage dependent reactive power capability limits with set-point characteristics

8. The consultancy firm will be required to transfer the knowledge to EPC staff during the study and this will involve acquisition of four copies of the tool used for power system simulation and training staff on how to use it.

4.0 Technical Proposal

The consultant shall present a complete technical proposal on how he/she proposes to carry out the works. The proposal shall consist but not restricted to the following

The consultant must have the following credentials in order to be considered for the job

1. Methodology

    a. Schedule of works

    b. Work Plan

2. Evidence of qualification
    a. Holder of an engineering degree in Electrical Engineering or a related field
    b. Membership of an engineering Institute
    c. An updated Curriculum Vitae
3. Profiles of team if there are more than one
    a. Qualifications
    b. Experience
4. Experience
    a. A matrix of similar projects the consultant has worked in. Provide a written description of the projects, the Term of References and the outcome results
    b. Evidence that the consultant was the main engineer or Team Leader in the projects listed above with referees
5. Duration of the works. *Note - The consultant must be able to mobilise within two weeks of being awarded the contract*

5.0 Key Deliverables

Index	Deliverable Title	Description
1	Power System Review (Current Network)	Conjunction with data collection – a review of EPC's current network and revision of current PowerFactory models where applicable and justified.
2	Power System Study	As described in Section 3
Technical Direction – Proposals & Recommendations for path to 2025		
3	Inertia Emulation	Propose solution(s) in replacing conventional inertia provision in a grid that is particular to Samoa's generation mix and forecasted renewable penetration expansion. Recommended technical characteristics of the solution(s) to be included – inverter and governor controller modifications, with or without ESS, etc. Justification via DIgSILENT Power Factory modelling and simulations

		required.
4	Voltage Regulation	Propose solution(s) in delivering stable voltage levels across the EPC grid transmission/distribution, in a grid that is particular to Samoa's generation mix and forecasted renewable penetration expansion.
5	Fault Current Proposal	Propose solution(s) in replacing conventional fault current provision in a grid that is particular to Samoa's generation mix and forecasted renewable penetration expansion..
6	Adaptive Protection System	Propose solution(s) in modifying EPC's current protection system as a result of expected changes along network dynamics in the transition to 100% RE grid. Recommended technical characteristics of the solution(s) to be included – SEL relay settings, SEL relay modules (cards) specifications, adaptive protection system,
100% RE Transition Master Plan - Reports & Models		
9	Final Report – EPC 2025 Master Plan	The report will guide EPC's next steps in its transition to a 100% renewable and sustainable grid. Recommended to document the steps and technical direction/proposal items in a time-driven manner.
10	DIgSILENT PowerFactory Files – handover and manuals	The Consultant/Consultancy Firm will handover Power Factory files used in the study. It is important that the handover will include manuals to describe the characteristics of each operation scenario, simulation parameter and result, study cases, model changes (from original EPC update), to name a few.

5.0 Selection Criteria

All proposals will be evaluated against the following criteria

1. Qualifications
2. Experience

3. Bid Price. Bidders are allowed to submit prices in the following currencies

    a. EURO

    b. US

    Australian Dollar

    c. New Zealand Dollar

    d. Samoan Tala

    All bid prices will be converted into Samoan Tala for evaluation purposes

    SCHEDULE

	DEFINITION OF UNIT	UNIT COST
	Complete Protection Study for EPC as pre the SCOPE	

Payment will be made once all the works have been completed and the final report is officially received by EPC

6.0 EPC's Role

EPC will provide the following

1. Assign one of its engineers to work with the consultant during the works. The EPC engineer will accompany the consultant to the sites, provide any data that is required for the study, coordinate site visits, organise meetings with relevant EPC personnel and any other requests from the consultant in regards to the project.
2. Provide a desk and office space
3. Provide internet connection for the consultant
4. Provide transport for the consultant to the sites

7.0 Instructions

1. All proposals are to be submitted to EPC, Level 5 TATTE Building, Sogi to the attention of Fui Tupai Mau Simanu, Chief Engineer Quality Assurance & Development

2. Electronic submissions are accepted, email simanum@epc.ws

3. All enquiries or clarifications can be forwarded to the Chief Engineer QA&D on the email address stated in (2) above